

# Biological Control of Insect Pests

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## 1. INTRODUCTION

The term biological control is generally applied to the use of living organisms as pest control agents. The agents involved in the biological control are predators — free living organisms which kill their prey and require a number of preys to complete their development, e.g., lady bird beetles, chrysopids, spiders, etc; parasitoids — often about the same size as their hosts, each requiring only one host for its development, e.g., braconids, encyrtids, eulophids, etc., and entomopathogens — develop inside the body of the hosts and in each host millions of organisms can develop, e.g., viral, fungal and bacterial diseases. Besides these, several protozoa, nematodes and predatory vertebrates also play a major role in pest suppression.

In India, biological control work was initiated long ago, but with the establishment of Commonwealth Institute of Biological Control Station at Bangalore, efforts were made to introduce exotic natural enemies for evaluation against key fruit pests. In 1977, the ICAR established an All India Coordinated Research Project on Biological Control to conduct systematic studies on various aspects of biological control.

Incidentally, the first spectacular success in classical biological control was achieved on citrus when the lady bird beetle, *Rodolia cardinalis* (Mulsant) was introduced in California, USA from Australia, for the suppression of cottony cushion scale, *Icerya purchasi* (Maskell). In India, efforts have been made for achieving success in biological suppression of fruit pests. The work on biological suppression of horticultural pests has been reviewed earlier (Singh, 1985). In this chapter, work done on biological suppression of fruit pests is reviewed.

## 2. CONTROL OF FRUIT PESTS

### 2.1 Apple

#### 2.1.1 San Jose Scale, *Quadraspidiotus perniciosus* (Comstock)

*Q. perniciosus* is one of the most serious pests of apple and many other deciduous fruit trees in Kashmir, Himachal Pradesh and Uttar Pradesh. The waxy covering of the scale renders it less prone to chemical than biological control measures.

A number of coccinellid beetles *Chilocorus bijugus* Mulsant, *C. rubidus* Hope, *Pharoscyrnus flexibilis* (Mulsant) and *Sticholotis marginalis* Kapur, etc. (Kapur, 1956) have been recorded feeding on this pest; the first mentioned has been recorded earlier (Rahman, 1940b), but these beetles are unable to give the desired natural control. Attempts have been made recently to utilize *C. bijugus* and *P. flexibilis*, the coccinellids were introduced from Jammu and Kashmir to Thanedhar areas of Himachal Pradesh. Both the predators have not only established but are also providing reasonable control of San Jose scale. The adults survived the winter and the beetles were observed 10 km away from the release site in the next season (Rawat *et al.*, 1988b).

Fungicides carbandazim, (Bavistin) mancozeb (Diathane M-45) and captofol (Foltaf 80 w) were safe to *C. bijugus* (Thakur *et al.*; 1989). First effort made in 1953 to establish exotic parasitoid *Encarsia perniciosi* (Tower) (origin: Far East) from California was unsuccessful (Rao *et al.*, 1971). In 1958 and 1960, three strains of the parasitoid, viz., Californian, Russian and Chinese were introduced. In addition, (*Aphytis diaspidis* How., origin : Japan) was introduced from California. All the strains were established, the Russian strain of the parasitoid gave 89 per cent parasitism in Himachal Pradesh. *A. diaspidis* in combination with *E. perniciosi* gave 86.5 per cent parasitism. In the beginning, low parasitism by Chinese strain was attributed to small number of parasitoids released (Jolly, 1961-62). In Kashmir, the Russian and Chinese strains appeared to be superior to Californian and Illinois strains. American and Chinese strains of *E. perniciosi* were also released in the Kumaon hills of Uttar Pradesh, the population of the pest was reduced by about 95 per cent (Sahai and Joshi, 1965). Resurgence of San Jose scale in many areas has probably been caused due to application of fungicides for the control of apple scab and mixing of some of the insecticides in these sprays. In Kashmir, releases of *E. perniciosi* and *A. proclia* (Walker) resulted in an increase of parasitism from 8.9 to 64.3 per cent (Anon., 1984). Subsequent experiments showed an increase of parasitism from 4.97 and 15.60 to 9.13 to 40.20 per cent (Masoodi and Trali, 1987). The studies on the biology of *E. perniciosi* revealed that the multiplication rate of parasitoid was over 10 times (Rao and Rao, 1960). Out of the pesticides tested, insecticides proved highly toxic but the fungicides were harmless to *E. perniciosi* (Anon., 1984, 1985).

Coccinellid predators *Chilocorus kuwanae* Silv. and Nitidulid *Cybocephalus gibbulus* Erickson from Japan were evaluated at Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh by the erstwhile CIBC, Indian Station, Bangalore, and *Sticholotis madagassa* Weise and *Lindorus lophanthæ* Blaisd at Kashmir by Central Biological Control Centre, Srinagar. But the beetles failed to create any impact and even could not be recovered.

#### 2.1.2 Woolly Aphid, *Erisoma lanigerum* (Hausmann)

*E. lanigerum*, a native of eastern United States, was first noticed in 1909 in Shimla district on nursery stock imported from England (Rahman and Khan, 1941a). Since then it has spread to all the apple growing tracts in India. A number of indigenous

predators — *Ballia eucharis* Muls., *Chilocorus bijugus*, *Oenopia sauzei* Muls. and *Syrphus confrator* Wied. (Rahman, 1940b), *Coccinella septempunctata* Linn. *Harmonia* (*Adonia*) *variegata* (Goeze), *Adalia quadraspilota* (Hope), *Menochilus sexmaculatus* (Fabr.), *Metasyrphus balteatus* (DeGeer)), *Chrysoperla carnea* (Steph.) in Himachal Pradesh (P. R. Gupta, personal communication), and *Exochomus uropygialis* from Sikkim (Anon., 1960) have been recorded. In Kashmir valley, hills of Uttar Pradesh and Tamil Nadu also, such diverse fauna of predators are available but their utilisation has not been attempted.

For the suppression of woolly aphid (WA), an exotic eulophid endoparasitoid *Aphelinus mali* (Haldeman), a native of North America, has been used extensively throughout the world. It has already established in 42 of the 51 countries or areas into which it was introduced.

In India, the first consignment of *A. mali* was received in Saharanpur (UP) in 1930 from the Farnham House Laboratory of the Imperial (now Commonwealth) Institute of Entomology in England (Thompson, 1930). The parasitoid was not effective in Kumaon hills due to the activity of *Coccinella septempunctata* which fed on parasitised and unparasitised aphids alike and provided nearly complete control (Lal and Singh, 1945). But the parasitoid was quite effective in Kullu valley of Himachal Pradesh (Rahman and Khan, 1941b; Singh, 1942). The parasitoid has since then spread to Kashmir valley (Narayanan, 1957). *A. mali* was also released around Shimla and it has established well (Rahman, 1939). However, the current status of this parasitoid indicates that it gives good control in valleys, but is less effective on slopes. In mid-April 1940, *A. mali* was introduced from Kullu into apple growing areas at Coonoor in the Nilgiri hills. The parasitoid was released at Kodaikanal and Shambanagar in 1943. It has established in most of the woolly aphid infested orchards. *A. mali* was also sent to Shillong from Coonoor in April, June and October 1963. In 1964, further release of *A. mali* were made and the parasitoid was firmly established (Chacko, 1967).

Recently, recolonisation of *A. mali* was conducted in Kullu, Shimla, Solan and Sirmour districts of Himachal Pradesh and Chattagram, Delina, Khannabal and Hazratbal areas of Jammu & Kashmir. The parasitism in the colonised places increased by over 50 per cent (Rawat and Pawar, 1987).

Most recent reports indicate that at some places, *A. mali* worked well, while at others *S. confrator* and *Chrysopa carnea* were effective collectively. In interaction, predators dominated over the parasitoids, diminishing the impact of natural parasitism (providing a clue that the parasitoid release may be directed only in areas or periods when predator activity is less). *S. confrator* was considered to be the most important natural predator. *Coccinella septempunctata*, although present in the field, did not prefer WA as its food (Rawat *et al.*, 1988b). This is contrary to the observations made earlier in Uttar Pradesh and the most recent findings at Mashobra, Himachal Pradesh. At Mashobra, *A. mali*, *C. septempunctata*, *S. confrator* and *C. carnea* were predominant

species. The coccinellids appeared in the orchards in the first week of April. The population of coccinellids remained high up to the end of second week and thereafter there was a gradual decline till the end of April. The predation impact was visible within 12 days of appearance of coccinellids on apple and within 24 days all the colonies were wiped out. The WA population again started building up in September but during this period there was hardly any activity of the coccinellid beetles. In July-August, 12 per cent population of the coccinellids was reduced by the parasitoid *Perilitus coccinellae* (Shrank) and entomophilic nematode — *Mermithid* sp. (P.R. Gupta, 1989 - Personal communication). The recommended concentration of commonly used fungicides against apple scab, i.e., Bavistin, Diathane, Foltaf, Difolaton and Captan had no adverse effect on the mortality and emergence of *A. mali* from mummified host bodies (Rawat *et al.*, 1988c).

The ineffectiveness of *A. mali* in certain areas could be because : (i) aphids were parasitised only on the aerial parts, (ii) climate was adverse (cool spring, early summer with rain), (iii) emergence of pest (threshold of development of *Erisoma* is 4°C and that of *Aphelinus* 8.6°C) did not synchronise with the parasitoid, and (iv) pesticides were used indiscriminately. There is a need to import fresh stocks as well as cold hardy strains of *A. mali* from different countries.

### 2.1.3 Codling Moth, *Cydia pomonella* (Linnaeus)

*C. pomonella* is a serious pest of apple and other fruits in Ladakh districts of Jammu & Kashmir. About 30 to 70 per cent of the apple fruits are rendered unmarketable by this pest (Singh, 1986). The larvae of the codling moth hibernate under the bark of the tree as well as in fruits and soil. Some birds like *Parus caeruleus*, *P. major* and *Passer domesticus* prey upon the overwintering larvae and a number of other natural enemies including a granulosis virus disease of the larvae cause considerable mortality. In spite of this, the pest continues to cause serious damage in apple growing areas of Ladakh (Khaltse, Nurla, Nemo, Sapol, Basgo, Leh, Saboo, Kargil, etc.).

Two exotic egg parasitoids *Trichogramma embryophagum* Htg. and *T. cacoeciae pallidum* Mayer were evaluated (Pawar *et al.*, 1980). Based on the results, weekly releases of the egg parasitoids of codling moth are recommended. A survey for consecutive two years (Singh, 1986) brought out the need to initiate control measures by monitoring of moth by large scale use of pheromones, conservation of natural enemies, synchronization of the first release of egg parasitoid, *T. embryophagum*, with the first appearance of the moth, subsequent releases at weekly intervals at 2000 per tree and large scale production and spray of granulosis virus of the moth at  $8 \times 10^7$  virus capsules/ml at fortnightly interval. Fortunately, the codling moth has not crossed the Zojila Pass and it may be possible to check the pest in Ladakh region itself if proper measures are adopted.

### 2.1.4 Plum Scale — *Eulecanium tillae* (L.)

*E. tillae* is a serious pest of apple and plum in Himachal Pradesh. *E. tillae* was parasitised by the aphelinid *Coccophagus ishii* sp. n. Comp. up to 7.2 per cent and adult

female scale by encyrtid *Blastothrix* sp. *sericea* Dalman to the extent of 40.7 per cent (Sharma and Dogra, 1986).

### 2.1.5 Indian Gypsy Moth, *Lymantria obfuscata* Wlk.

*L. obfuscata* is a common pest of apple, poplar, willow, walnut, peach, plum, cherry, etc. in Kashmir. The pest is widely distributed in Badgam, Pulwama, Anantanag, Srinagar and Baramula districts (Anon., 1984). The intensity of infestation appears to be higher in humid areas. It has been found to cause severe damage to many tree and fruit crops in temperate regions of Himachal Pradesh and UP. About 70 natural enemies have been recorded destroying various stages of *L. obfuscata*. Egg parasitoid *Anastatus kashmirensis* Mathur; larval parasitoids *Glyptapanteles indiensis* (Marsh), *G. flavicoxis* Marsh, *G. liparidis* (Bouche), *Cotesia melanoscela* (Ratzeburg), *Hyposoter lymantriae* Cushman, *Rogas indiscretus* Reardon, *Exorista rossica* Mesnil, *Palexorista conspicua* Meigen; pupal parasitoids *Brachymeria intermedia* (Nees) and *B. lasus* (Walker) are the dominant parasitoids of Indian gypsy moth (Dharmadhikari *et al.*, 1985). In addition to these pupal parasitoids, *Pimpla laothoe* Cameron, *Theronia atalantae* (Poda) and *Tetrastichus* sp. from many areas in Kashmir (Anon., 1984), as well as carabid predator, *Calosoma himalayanum* (Gestro) (Rishi and Shah., 1985), have been recorded as population regulatory factors of the Indian gypsy moth. But the reasons for outbreaks of this pest causing extensive defoliation are yet to be determined. As the spraying of trees is difficult, conservation of natural enemies and inundative release of the effective egg/young instar larval parasitoids has to be tried on a large scale for controlling this pest.

### 2.1.6 Mites

*Amblyseius finlandicus* (Dudm.) was the most common predator on mite *Tetranychus urticae* Koch. attacking apple in Kashmir. The life cycle of the host was synchronised with that of the predator. Out of acaricides/fungicides tested, 0.02 per cent Captan and 0.01 per cent Benlate were effective against *T. urticae* and less toxic to *A. finlandicus* (Rishi and Rather, 1983).

## 2.2 Citrus

Extensive survey was conducted on the natural enemies of citrus pests in Kodagu, Karnataka (Singh, 1980, 1985).

### 2.2.1 Citrus Leaf Miner, *Phyllocnistis citrella* (Staint.)

Unidentified egg parasitoids, *Sympiesis* sp., *Kratoysma* sp., *Bracon* sp., *Pediobius* sp., *Tetrastichus* sp. (miser group), *T. phyllocnistoides* (Narayanan), *Cirrospilus* sp. and *C. quadristriatus* were recorded in Kodagu. Three larval parasitoids, viz., *Amatellon* sp., *Tetrastichus* sp. and *Elasmus* sp. were earlier recorded parasitising only up to

33 per cent (Narayanan *et al.* 1957). *Bracon* sp., *T. phyllocnistoides* and *C. quadristriatus* were reported from South India (Nair, 1975). An eulophid parasitised 30 per cent of the population from September to December in Delhi (Pruthi and Mani, 1945) and larval parasitoid *Ageniaspis* sp. was reported to sporadically parasitise 80 per cent of the larvae (Atwal, 1964).

## 2.2.2 Citrus Leaf Eating Caterpillar, *Papilio demoleus* (Linn.)

*Dusona* sp., *Melalophacharops* sp. (perhaps *M. tamanukii* Uchida), *Pteromalus puparium* (L.), *Brachymeria jambolana* Gahan, *Holcojoppa coelopyga* Morley, *Blepharipa* sp., *Apanteles papilionis* Viereck, *Serratia marcescans*, *Fusarium* sp. and *Mesochorus* sp. (Hyperparasite of *Melalophacharops* sp. and *A. papilionis*) have been reared from caterpillars and pupae in Kodagu. *B. jambolana*, a primary parasitoid, has been recorded as hyperparasitic on another primary parasitoid, *Melalophacharops* sp. Except *P. puparium* and *A. papilionis*, all are new records from this region (Singh, 1985). Other records include egg parasitoids, *Trichogramma chilonis* Ishii (Pruthi and Mani, 1945; Krishnamoorthy and Singh, 1986) and *Telenomus* sp. nr. *incommodus* Nixon. *T. chilonis* parasitised up to 75.86 per cent and *Telenomus* sp. 78 per cent in February (Krishnamoorthy and Singh, 1986; Krishnamoorthy, 1987). *A. papilionis* was the dominant parasitoid of caterpillars at Bangalore and *T. chilonis*, *T. incommodus* and *A. papilionis* caused a cumulative parasitism of 88 per cent (Krishnamoorthy and Singh, 1988). Pupae of *P. demoleus* were attacked by *P. puparium* (Misra and Pandey, 1965), *Brachymeria* sp. (Singh, 1967; Misra and Pandey, 1965) and *Erycia nymphalidephaga* Bar (Modawal, 1940). Tachinid, *Ugimyia sericaiae* Cornalia, has also been reported from *P. demoleus* (Thompson, 1946). Most of the parasitoids of *P. demoleus* also attack another common species of butterfly *P. polites* L. in Kodagu and other places. *T. chilonis*, *Melalophacharops* sp. and *A. papilionis* could be utilised for the biological suppression of butterflies attacking citrus.

Dipel, a commercial formulation of the bacterium, *Bacillus thuringiensis* Berl., has been found to be very effective in Kodagu against the citrus butterfly caterpillars at 0.05 per cent concentration. It also effectively killed *Heliothis armigera* (Hbn.) and *Prays citri* Milliere feeding on citrus inflorescence, but its use will be limited in Karnataka in view of the prohibitory orders in the State against use of *B. thuringiensis* which is toxic to mulberry silkworms (Singh, 1980, 1985). Earlier, the susceptibility of citrus butterfly caterpillar, *Papilio demoleus*, to 0.2 per cent Bactospeine (Sundara Babu, 1969) and Thuricide 90 TS Flowable (containing 15 billion viable spores/gram) (Narayanan and Jayaraj, 1974) had been reported. At Bangalore, a protozoan (*Nosema* sp.) has been isolated from the citrus butterfly larvae (Anon., 1980) and recently a cytoplasmic polyhedrosis has also been isolated (Narayanan and Gopalkrishna, 1987). *Neoplectana carpocapsae* Dutky were applied at 600,000 nematodes per tree which resulted in 63.3 per cent kill of third instar butterfly caterpillars and 67 per cent mortality of fourth and fifth instar caterpillars (Srivastava, 1978).

### 2.2.3 Other Lepidopterans

On *Tonica zizyphi* Stainton, *Apanteles* sp., *Pristomerus* sp. and *Brachymeria euploeeae* (Westwood) have been recorded in Madhya Pradesh (Gupta, 1954). In Punjab, the extent of parasitism by *Pristomerus* sp. was higher in July and by *A. machaeralis* Wilkinson during June (Sharma and Batra, 1989).

Entomopathogenic fungus, *Gibulella* sp., parasitised the caterpillars of *Indarbela tetraonis* Moore in Delhi (Batra and Kumar, 1958). Use of fungus *Aspergillus candidus* Link. has been suggested for the biological suppression of *Indarbela* (Singh and Singh, 1984).

The orange hair streak moth, *Tarucus theophrastus* Fab., was parasitised by *Telenomus trasversiceps* Nixon and *T. otonex* Nixon (Nair, 1975).

Over two dozen parasitoids have been recorded from fruit piercing moth *Achaea janata* (Linn.) (Rao, 1969). Egg parasitoid, *Trichogramma chilonis*, and larval parasitoid, *Microplitis maculipennis* Szep., are important. The eggs of fruit sucking moth, *Othreis fullonica* CL., were successfully parasitised by *Trichogramma chilonis* which suggests the possibility of utilising *T. chilonis* for the control of this pest (Dodia et al., 1986).

### 2.2.4 Citrus Psylla, *Diaphorin citri* Kuwayama

Nymphs of the psyllid were predated by 12 species of coccinellid beetles (Sharga, 1948). In Punjab *Coccinella septempunctata* L., *C. repanda* Thunb., *Menochilus sexmaculatus* (F.), *Chilocorus nigrinus* (F.), *Brumus suturalis* F., a syrphid fly and *Chrysopa* sp. were found feeding on developmental stages of citrus psylla (Hussain and Nath, 1927; Bindra, 1970). *Temarixia radiata* (Waterson) was the most common parasitoid of nymphs of this pest (Rahman, 1940a; Pruthi and Mani, 1945; Atwal, 1962a; Nair, 1975). The parasitoid is quite active from July to November (Hussain and Mathur, 1923; Hussain and Nath, 1927; Bindra, 1969, 1970). *T. radiata* sometimes gives up to 95 per cent parasitism of the nymphs. It has recently been introduced to Reunion where it has given effective suppression of citrus psylla.

### 2.2.5 Black Citrus Aphid, *Toxoptera aurantii* (B. de F.)

*Parasatoma cephalotes* Ashmead, *Lipolexis scutellaris* Mackaur, *Coelophora biplagiata* Swartz, *Coccinella septempunctata*, *Menochilus sexmaculatus*, *C. repanda*, *Pullus xerampelinus* Ms., *Nephus* sp., *Chrysopa* sp., *Paragus serratus* (Fabr.), *Dideopsis aegrota* (Fabr.), *Ischiodon scutellaris* (Fabr.) and *Cardiastethus pygmaeus* Poppins were recorded in Kodagu. Further search for natural enemies of this pest is necessary because neither *Aphelinus* nor *Aphidius*, the common parasitoids of aphids have been recorded.

### 2.2.6 Green Scale, *Coccus viridis* (Green)

*Microterys* sp., *M. flavus* (Howard), *Anicetus annulatus* Timberlake, *Gyranus* sp., *Tetrastichus* sp., *Coccophagus* sp. (*Lycimnia* group), *C. cowperi* Gir., *C. bogoriensis* Kon., *Cheiloneromyia javensis* Gir., *Chilocorus circumdatus* Sch., *C. nigrinus*, *Pharoscymnus horni* Wse., *Cryptolaemus montrouzieri* Muls., *Chrysopa* sp., *Verticillium lecanii*, *Entomophthora* sp., *Hypocrella olivacea*, *Nectria* sp., *Podonectria* sp., *Fusarium* sp. and *Cladosporium* sp. were recorded in Kodagu. Around Bangalore, *Aneristus ceroplastae* How. and *Encyrtus lecaniorum* Mayr caused 43 per cent parasitism in July (Tandon, 1985). On coffee, 18 parasitoids have been recorded. The frequently recorded parasitoids include *A. ceroplastae*, *Coccophagus* sp., *C. cowperi*, *Marietta javensis* (Howard) (hyperparasite), *A. annulatus* and *Encyrtus lecaniorum* (Mayr) (Srivastava, 1987). Some of these also parasitise *C. viridis* on citrus in south India. The natural enemies are capable of suppression of *C. viridis* in undisturbed ecosystem.

At Central Horticultural Experiment Station, Chethalli, a combination of the fungal suspension *Verticillium lecanii* containing  $16 \times 10^4$  spores/ml and one-tenth the recommended dose of quinalphos sprayed just before the onset of rainy season was found to give effective control of *Coccus viridis* where the light interception was 900-14100 lux. Where the light interception was more than 4800-23900 lux, this treatment proved less effective (Singh, 1980, 1985).

### 2.2.7 Brown Scale, *Saissetia coffeae* (Walk.)

*Microterys* sp., *Anysis* sp., *Coccophagus* sp., *C. cowperi*, *Chilocorus circumdatus*, *C. nigrinus*, *Pharoscymnus horni*, *Cryptolaemus montrouzieri*, *Chrysopa* sp. and *Verticillium lecanii* were recorded from Kodagu. *Aneristus ceroplastae*, *Anysis saissetiae* (Ashm.), *Cardiogaster fusciventris* Motsch., *Coccophagus flavescens* How. and *Encyrtus adustipennis* Motsch. have been reported parasitising this species (Pruthi and Mani, 1945).

### 2.2.8 Circular Purple Scale, *Chrysomphalus aonidium* (L.)

*Microterys* sp., *Tetrastichus* sp., *Aphytis* sp., *A. mytilaspidis* (Le Baron), *Coelophora biplagiata* Swartz., *Chilocorus circumdatus*, *C. nigrinus*, *Pharoscymnus horni* and *Nectria* sp. were recorded in Kodagu.

### 2.2.9 Purple Scale, *Lepidosaphes beckii* (Newm.)

*Microterys* sp., *Adelencyrtus femoralis* Compere and Annecke, *Aphytis* sp., *A. mytilaspidis*, *Tetrastichus* sp., *Coelophora biplagiata*, *Chilocorus circumdatus*, *C. nigrinus*, *Pharoscymnus horni* and *Nectria* sp. were recorded from Kodagu. In Wynaad (south India), it was attacked by entomopathogenic fungus, *Sphaerostelbe auranticola* (Ramachandran, 1954).

### 2.2.10 Citrus Red Scale, *Aonidiella auranti* (Mask.)

*Aphytis* spp. were the common parasitoids recorded. *A. fisheri* De Bach and *A. nr. hispanicus* (Mercet) were recorded at Guwahati, Assam (De Bach, 1959). Apart from *Aphytis* spp., *Coccobius* sp. *Encarsia* sp., and *Pterotrix koebeli* (Howard) have recently been reported (Anon., 1984a). Predators *Chilocorus nigritus*, *Scymnus quadrillum* Motsch. (Pruthi and Mani, 1945), entomopathogenic fungus *Attractium indica* Chona and Munjal, *C. circumdatus* and *C. hauseri* Wse. (Rao, 1969) have been reported attacking red scale. Suitable species/strains of *Aphytis* available for suppression of red scale need to be evaluated in different citrus growing areas of the country.

### 2.2.11 Other Diaspine Scales

From other diaspine scales infesting citrus, *Eretmocerus* sp. *Azotus* sp., and *Adelencyrtus* sp., have been reared from *Pinnaspis aspidistrae* (Sign.) in Andhra Pradesh (Nagalingam, 1980). *Aphytis chrysomphali* (Mercet), *Phycus* sp. (near *flaviventris* How.), *Tetrastichus purpureus* Cam. and *Comperiella bifasciata* from Namkum (Bihar) (Glover, 1935) and *C. bifasciata* from *A. citrina* Coquillett at Bombay and Pune were reared (Compere, 1961). *Pharoscymnus horni* was considered to be the most promising predator in India (Compere, 1961).

### 2.2.12 Citrus Blackfly, *Aleurocanthus woglumi* Ashby

*Encarsia* sp., *Encarsia clypealis* Silv., *E. citrina* (Craw.), *Amitus* sp., *Pullus xerampelonus*, *Chrysopa* sp., *Verticillium lecanii*, *Aschersonia* sp. and *Cladosporium* sp. were recorded in Kodagu. *Encarsia bennetti* Hayat has also been described (Hayat, 1984). Parasitoids *Encarsia* sp., *E. clypealis*, *A. hesperidium*, *Eretmocerus serius* Silv., *En. sp. nr. citrifolia*, *E. divergence* Silv. and *E. merceti* Silv. and predator *Acletoxenus* sp. have been recorded in north India (Smith, 1950). At Guwahati, *P. divergence* and *E. merceti* were the dominant parasitoids accounting for 90 per cent of the total parasitism (Smith, 1950). While in Pune, 80-90 per cent parasitism by *E. clypealis* was recorded but *A. hesperidium* and *E. clypealis* caused 80 per cent parasitism in Bombay and Bangalore. *A. hesperidium* L., *E. opulenta* Silva., *E. clypealis* and *E. smithi* Silv. were sent from India and Pakistan to Mexico during 1948-50 for suppression of citrus blackfly. All the parasitoids have established (Clausen, 1958; Rao et al., 1971).

### 2.2.13 Citrus Whitefly, *Dialeurodes citri* (Ashm.)

From citrus whitefly, *Encarsia lahorensis* (How.) has been recorded as the key parasitoid in most of the distribution zones of the pest. *Aphelinus fuscipennis* How. has also been recorded. The predators often associated with this pest were *Brumus suturalis*, *Cryptognatha flavescens* Motsch, *Micraspis cardoni* (Wse.) and *Chrysopa* sp. (Hussain and Khan, 1945; Pruthi and Mani, 1945). Among entomopathogenic fungi, *Aegerita webberi* Fawcatt has been recorded at Saharanpur (Woglum, 1913), *Cladosporium* sp.

in Punjab (Hussain and Khan, 1945; Saini, 1964) and *Aschersonia papillata* in Kumaon hills (Bose, 1953). The last mentioned entomopathogen has been evaluated and recommended for use in south India (Dharmaraju and Reddy, 1975).

#### 2.2.14 Oriental Mite, *Eutetranychus orientalis* (Klien.)

*Amblyseius* sp., *Stethorus* sp., *Pullus xerampelonus* and *Scolothrips* sp. were recorded in Kodagu. A coccinellid, *Scymnus gracilis* (Motsch.) and a predatory thrip, *Scolothrips indicus* Priesner and four predatory mites, *Pronematus* sp., *Amblyseius cucumeris* Oudemans, *A. habisci* Chant and *Agistemus* sp. were recorded feeding on oriental red mite, *E. orientalis* (Sadana and Kanta, 1971). In addition, *Typhlodromus rhenanus* (Ouds.) and *A. habisci* also attacked *Brevipalpus californicus* Banks (Gupta *et al.*, 1971).

Chrysopids, thrips, coccinellids, itonidids and hymenopterans destroy large number of citrus red mite (Pruthi and Mani, 1945). *Arthrocnodax* sp., *Chrysopa* sp. and *Hemerdeius* sp. predate on citrus red mite and other species of mites. In Punjab, coccinellid beetle *S. gracilis* and a chrysopid larva were observed to be predacious on citrus red mite (Sethi *et al.*, 1964). Out of *Amblyseius largoensis* (Muma), *A. aeralis* (Muma), *A. rickeri* Chant and *A. finlandicus* (Oudemans) — *A. aeralis* was a common predator (Rao, 1969).

#### 2.2.15 Common Mealy bug, *Planococcus citri* (Risso)

*Anagrus* sp., *Blephyrus insularis* (Cam.), *Diversinervus* sp., *Tetrastichus* sp., *Microterys* sp., *Cryptochaetum* sp., *Pullus coccidivora* Ayyer, *P. pallidiocollis* Mst., *Nephus* sp., *Chrysopa* sp., *Micraspas cardoni* (Wse.), *pseudaspidimerus uttami* Kap., *Cryptolaemus montrouzieri* Muls. and *Spalgis epius* West wood were recorded at Kodagu. In Assam, *C. montrouzieri* and *Entomophthora fumosa* have been observed (Chowdhury and Majid, 1954).

For the biological control of mealy bug, a simple method involving the multiplication of host on ripe pumpkins for mass rearing the lady bird predator, *Cryptolaemus montrouzieri* (of Australian origin), propagation, field release of predator on citrus and other hosts was evolved at Kodagu (Singh, 1978; Singh, 1989). In 34 to 52 days, each pumpkin yields 168 beetles at a cost of 10 paise per beetle. Patrolling of ants on the trunk was stopped by a band of 5 per cent diazinon granules leaving one foot space around the trunk. Ten beetles (starved overnight) per plant were released 24 hours after the application of diazinon band. The impact was visible within a week and by the fifth week, the population of mealy bugs was reduced to a negligible level. Release of the predator have to be repeated annually whenever the mealy bug appears.

An exotic parasitoid, *Leptomastix dectylopil* How., with superior searching ability was imported from West Indies in 1983 (Nagarkatti *et al.*, 1987). It preferred to parasitise 15-20 days old *P. citri* completing its development in about 15 days (Krishnamoorthy,

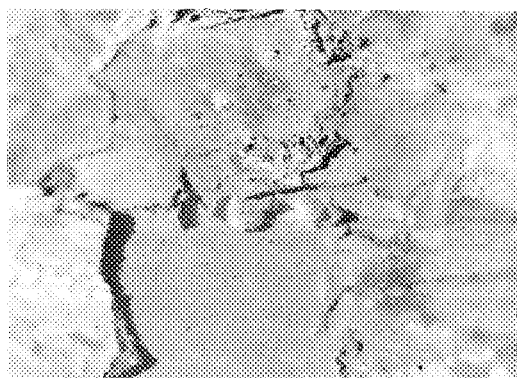


Fig. 1 : Hibernating codling moth larvae on apple trunk (exposed).

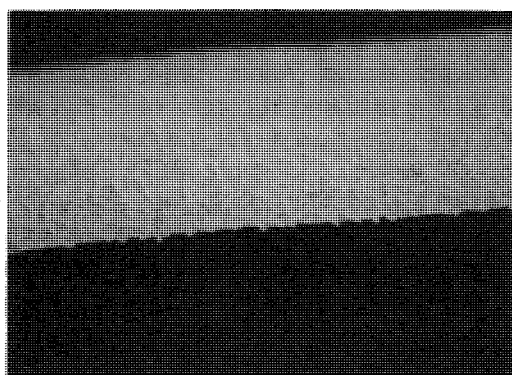


Fig. 2 : Apple twig fully covered by San Jose scale.

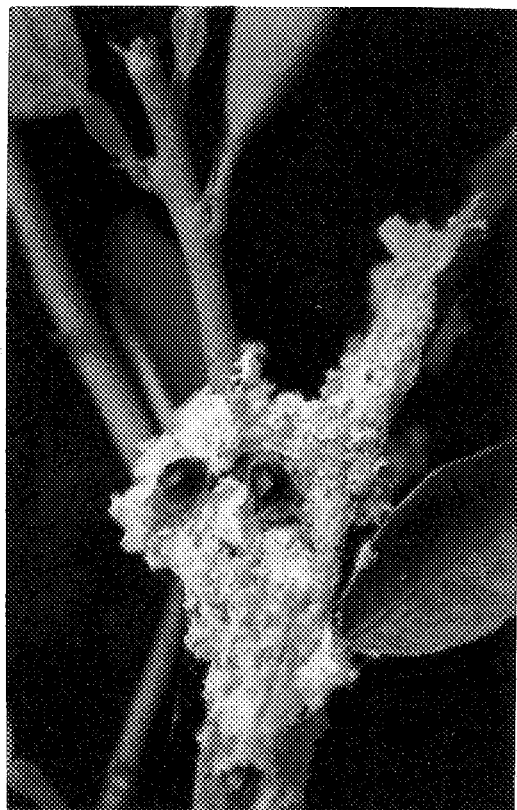


Fig. 3 : Citrus twig infested by mealy bug *Planococcus citri*.

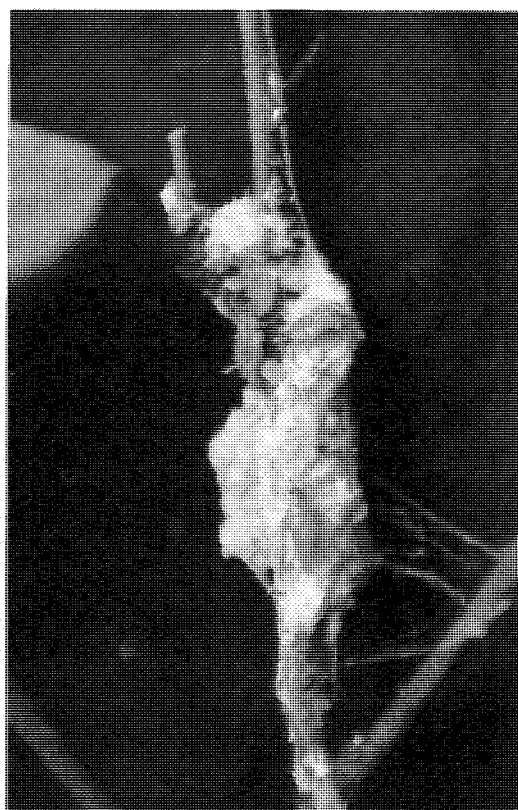


Fig. 4 : Chrysopid larvae feeding on citrus mealy bug.

1988). The mummies of *Leptomastix* could be stored for about 20 days at 15°C and 70-80 per cent relative humidity (Anon., 1986; Krishnamoorthy 1989). Field release of *Leptomastix* resulted in its establishment in the mixed plantations of citrus and coffee in Kodagu district (Anon., 1984; Nagarkatti *et al.*, 1987) and in citrus orchards around Bangalore resulting in control of *P. citri* within 3-4 months. No insecticidal sprays were required subsequently for the control of *P. citri* in the following season (Anon., 1984; Krishnamoorthy and Singh, 1987). Carbaryl, dimethoate, monocrotophos and phosalone had residual contact toxicity for 5-7 days to *Leptomastix* adults but synthetic pyrethroids proved highly toxic even after 15 days (Anon., 1985). The predator *C. montrouzieri* was found to feed the parasitised mealybug in the early stage of parasitoid development but not the mummified mealy bugs (Anon., 1986).

### 2.2.16 Other Mealy bugs

Over a dozen parasitoids have been recorded on mealy bug *Nipaecoccus viridis* (Mask.). *Anagyrus dactylopii* How. was dominant, parasitising up to 90 per cent in the field (Ali, 1957; Subba Rao *et al.*, 1965).

The fluffy mealy bug, *Pseudococcus filamentosis* Cockerell, was reported to be predated upon by coccinellid *Rodolia cardinalis*, *Chrysopa* sp. and a syrphid fly larva (Atwal, 1926b). *R. amabilis* Kapur, *R. breviscula* Weise., *R. netara* Kapur, *R. minima* Kapur, *R. fumida* Mulsant, *Cryptochaetum grandicorne* Rond., *C. iceryae* (Williston) and *uzophera cocciphaga* Hampson were recorded feeding on *Icerya purchasi* Maskell (Subramanian, 1954, 1955). But this pest was brought under control by the introduced lady bird predator *R. cardinalis* (Rao and Kamath, 1966). Release of 8-10 beetles on each of the moderately infested plant is suggested.

## 2.3 Grape

### 2.3.1 Mealy bug, *Maconellicoccus hirsutus* (Green)

*M. hirsutus* has become a major pest in south India in recent years. Survey conducted on natural enemies revealed that seven parasitoids and seven predators attack *M. hirsutus* in vineyards out of which the encyrtid, *Anagyrus dactylopii* (How.) and the coccinellid, *Scymnus coccivora* were promising (Anon., 1986; Mani *et al.*, 1987). *A. dactylopii* male and female completed their development in 14.8 and 22 days and a progeny of 39.3 was produced (Mani and Thontadarya, 1988b). Third instar nymph and adult female of *M. hirsutus* were found suitable for breeding of *A. dactylopii* (Mani and Thontadarya, 1987b). The pesticides dichlorvos (0.2 per cent), diazinon (0.05 per cent) and phosalone (0.07 per cent) were non-toxic to immature stages and adults of *A. dactylopii* (Mani and Thontadarya, 1988a). The coccinellid predator *S. coccivora* completed its development on *M. hirsutus* in about 20-30 days, adult males and females lived for 60.5 and 68.7 days. Each female produced 46.5 eggs. Grub consumed about 308 eggs or 62 nymphs or 6.6 adult females (Mani and Thontadarya, 1987b). However, *C. montrouzieri* was more voracious, feeding about 881 eggs or 259 nymphs or

27.6 adult females (Mani and Thontadarya, 1987a). According to another estimate, *C. montrouzieri* males and females consumed 5577 and 4444 eggs of mealy bug (Jayaraman *et al.*, 1988). Under field conditions, a positive and significant relationship between the population of *A. dactylopii* and *M. hirsutus* was observed (Mani and Thontadarya, 1987c).

Release of 10 beetles of *C. montrouzieri* per vine could effectively suppress the grape mealy bugs in about 75 days of release (Mani and Thontadarya, 1988c; Ranga Reddy and Lakshminarayana, 1986). The insecticides dichlorvos, chlorpyrifos and all the commonly used fungicides at recommended concentrations were safe to all the stages of *C. montrouzieri*. Application of these pesticides can be combined with *Cryptolaemus* in the pest management programme (Mani and Thontadarya, 1988d; Ramesh Babu and Azam, 1987). Biological suppression of *M. hirsutus* was achieved in Egypt by introduction of parasitoid *Anagyrus kamali* Moursi from Java (Kamal, 1951). Efforts are being made to introduce this parasitoid into India.

### 2.3.2 Leaf Roller, *Sylepta lunalis* Guien

*S. lunalis* was reported to be parasitised by larval parasitoid *Apanteles clita* Nixon and prepupal parasitoid *Cardiochiles fulvus* Cameron (Odak and Dhamdhare, 1970).

## 2.4 Guava

### 2.4.1 Aphid, *Aphis gossypii* Glover

Coccinellids *Menochilus sexmaculatus*, *Scymnus latemaculatus* (Mots.), *S. castaneus* Sic., *Pseudaspidimerus circumflexus* (Mots.) and the syrphids *Ischiodon scutellaris* (F.) and *Paragus serratus* (F.) predate upon *A. gossypii*. In the absence of insecticidal applications, the coccinellid and syrphid predators gave complete control of aphids in guava orchards (Butani, 1974; Anon., 1987).

### 2.4.2 Green Shield Scale, *Chloropulvinaria psidii* (Maskell)

*Bothriophyne pulvinaria* sp. n. and *B. tachikawai* sp. n. (Agarwal *et al.*, 1984), *Coccophagus bogoriensis*, *C. cowperii* and *Aneristus* sp. were collected from *C. psidii* (Bennet and Hughes, 1959; Anon., 1988). Two predators, *Chilocorus nigritus* (F.) and *Menochilus sexmaculatus* have also been recorded (Anon., 1979, 1979a). However, *C. montrouzieri* was effective against this pest (Anon., 1987). *Scymnus* sp. was also recorded feeding on green shield scale.

### 2.4.3 Mealy bugs

The striped mealy bug, *Ferrisia virgata* (Ckll.), is a very serious pest of guava in south India. Many parasitoids and predators were recorded on *F. virgata* infesting guava plants (Anon., 1984, 1987). Release of *Cryptolaemus montrouzieri* controlled



Fig. 5

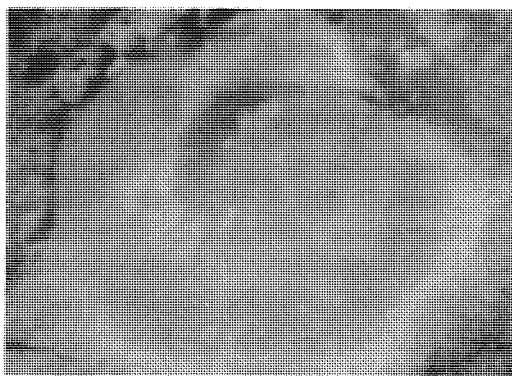


Fig. 7

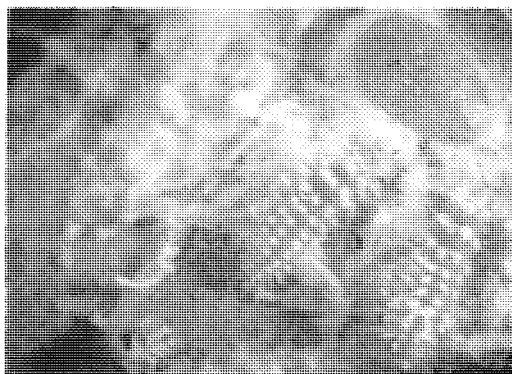


Fig. 9

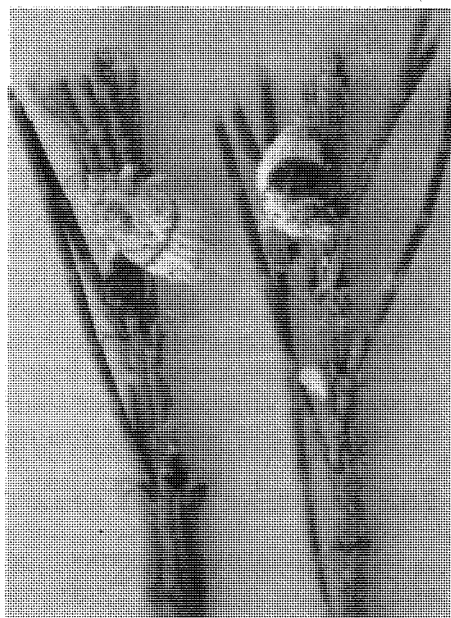


Fig. 6

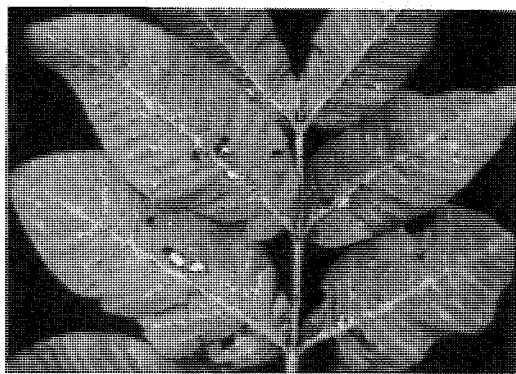


Fig. 8

Fig. 5 : Exotic parasitoid *Leptomastix dactylopii* parasitising citrus mealy bug.

Fig. 6 : *Rodolia cardinalis* feeding on cottony cushion scale.

Fig. 7 : Citrus black fly attacked by entomogenous fungus *Aschersonia*.

Fig. 8 : *Cryptolaemus montrouzieri* grubs feeding on mealy bug on guava.

Fig. 9 : Grubs of *Scymnus coccivora* feeding on mealy bug infesting grapes/

the pest effectively within 30 days of release in 1984 (Anon., 1984; Mani *et al.*, 1990). The efficacy of *Cryptolaemus* in controlling striped mealy bug was demonstrated in farmer's fields (Anon., 1988). In another trial, the parasitoid, *Anasius advena* Compere, and coccinellid, *Scymnus coccivora* Ayyar complimented the performance of *C. montrouzieri* in complete control of *F. virgata* (Anon., 1987). *P. citri* can be brought under effective control by releasing 10 predatory beetles, *C. montrouzieri* per plant.

## 2.5 MANGO

Survey for natural enemies of insect pests of mango has been conducted by several workers (Weber, 1951; Narayanan and Batra, 1960; Clausen *et al.*, 1965; Tandon and Lal, 1976, 1978, 1983; Srivastava and Tandon, 1980; Tandon, 1985 — Personal communication). The pest-wise list of natural enemies is given below.

### 2.5.1 Mango Mealy bug, *Drosicha stebbingi* (Green)

*Aulis vestitus* Muls., *Coccinella septempunctata* L., *C. transversalis* F., *Menochilus sexmaculatus* (F.), *Rodolia fumida* Muls., *Sumnius cordoni* Weise., *Cryptophora cicatrosa* Stoliczka, *Linyphia* sp., *Phidippus* sp., *Oxyopes shweta* Tikader, *Hersilia savigryi* Lucas, *Rhene indicus* Tikader, *Stagodyphus sarasinorum* Karsch, *Marpissa* sp., *Leptus* sp., *Bochartia* sp., *Tetrabrachys robusta* and *Gitona* sp. nr. *magnipalpis* Duda and *Beauveria bassiana* (Bals.) Vuill. were recorded from Malihabad (UP). Earlier records show that mango mealy bug was predated by several coccinellids including *R. fumida*, the chrysopid, *Chrysopa carnea* (Steph.) and drosophilid *Cacoxenus perspicax* (Knab) and parasitised by *Phygadeuon* sp. (Rahman and Latiff, 1944; Wadi and Batra, 1964; Varma *et al.*, 1976).

### 2.5.2 Mango Hopper, *Idioscopus clypealis* Letheirry

*Coccinella septempunctata*, *C. transversalis*, *Menochilus sexmaculatus*, *Araneus sinhagadensis* Tikader, *Cryptophora cicatrosa*, *Cheiracanthium danieli* Tikader, *Stagodyphus sarasinorum*, *Hersilia savigryi*, *Oxyopes shweta*, *Rhene indicus*, *Phidippus* sp., *Uloborus* sp., *Linyphia* sp., *Theridion indica* Tikader, *Marpissa* sp., *Tetrastichus* sp., *Beauveria bassiana*, *Verticillium lecanini* (Zimm.), *Aspergillus flavus* Link., *Pleospora infectoria* group, *Cladosporium* sp., *Hirsutella* sp., and *Isaria* sp. were recorded from Malihabad.

### 2.5.3 Mango Shoot Borer, *Chlumetia transversa* Walker

*Goryphus* sp., *Barcon greeni* Ashmead, *Meteorus* sp., *Araneus sinhagadensis*, *Stagodyphus sarasinorum* and *Serratia marcescens* Bizio. were recorded from Malihabad.

### 2.5.4 Mango Leaf Webber, *Orthaga euadrusalis* Walker

*Brachymeria lasus* (Walker), *Tetrastichus* sp., *Pediobius bruchicida* (Rondani), *Hormius* sp., *Cathartoides* sp., *Tetrastichus* sp., *Aspergillus flavus* Link., *Beauveria bassiana* and *Serratia marcescens* were recorded from Malihabad.

*Goniozus* sp. was recorded as an important larval parasitoid in Kerala (George and Abdurahman, 1985).

#### 2.5.5 *Diaspine Scale, Aspidiotus destructor* Signoret

*Aphytis chrysomphali* (Mercet), *Aneristus ceroplastae* Howard, *Chrysonotomia* sp., *Comperiella bifasciata* Howard, *Chartocerus* sp., *Thomsonisca desantisiellus* Shafee and *Chilocorus nigrinus* Fabr. were recorded from Malihabad.

#### 2.5.6 *Mango Coccid, Rastrococcocus Iceryoides* (Green)

*Anagyrus pseudococci* Girault, *Gyranusoidea* sp., *Praeurocerus viridis* Agarwal, *Allotropa* sp., *Microterys flavus* (Howard), *Dinocarsis* sp., *Promuscidea unfasciiventris* Girault, *Metastenus concinnus* Walker, *Tetrastichus* sp., *Cybocephalus* sp., *Scymnus* (*Pullus*) *coccivora* Ayer, *Monomorium floricola* (Jerdon), *Coccophagus* sp. and *Proctolaelaps* sp. were recorded from Malihabad. But *P. unfasciiventris* and *A. pseudococci* were important (Tandon and Lal, 1978). *P. isoliotus* (Alam) and *Tetrastichus* sp. have been reported earlier (Rawat and Jakhmola, 1970; Shafee *et al.*, 1975).

Predatory ants *Camponotus* sp., *Myrmicaria brunnea* Saunders and *Oecophylla smaragdina* (F.) and parasitoid *Allotropa* sp. have been reported in addition to the already mentioned *Anagyrus* sp. and *Praeurocerus viridis* (Narasimham and Chacko, 1988).

#### 2.5.7 *Mango Scale, Chloropulvinaria polygonata* (Ckll.)

*Aneristus ceroplastae*, *Metaphycus* sp. nr. *hederaceous*, *Tetrastichus* sp., *Anicetus annulatus* Timberlake, *Nicostartus* sp. and *Anagyrus* sp. were recorded from Malihabad.

#### 2.5.8 *Leaf Eating Caterpillar, Euthalia garuda* Moore

*Eurytoma* sp. was recorded on *E. garuda* from Malihabad.

#### 2.5.9 *Late Mango Mealy bug, Perissopneumon ferox* Newst.

*Rodolia fumida* and *Leptus* sp. were recorded from Malihabad.

#### 2.5.10 *Mango Leaf Gall, Procontarinia mattei* Kieffer and Cecconi

The hymenopterous parasitoids recorded in India include *Chrysonotomyia pulcherrima* (Kerrich), two undescribed *Chrysonotomyia* spp., two *Tetrastichus* spp., *Synopeas procon* Austin, *Inostemma oculare* Austin, *Trichacoides indicus* Jackson, *Ormyrus* sp., *Eupelmus* sp. near. *testaceiventris* (Mots.), *Gastrancistrus* sp. and *Aphanogmus* sp. Out of these *Chrysonotomyia pulcherrima*, *C. sp.* near *pulcherrima*,

*Eupelmus* sp. near *testaceiventris*, *I. ocular* and *Ormyrus* sp. have been shipped from India and released in Oman (Sankaran and Mjeni, 1985).

*C. pulcherrima*, *Anicetus* sp., *Megastigmus ameraeus* (Chandy Kurian), *Synopeas* sp. *Tetrastichus* sp. and *Amblydromella plebins* Chaudhri were recorded from Malihabad.

#### 2.5.11 Mango Shoot Gall *Psylla*, *Apsylla cistellata* Buckton

*Micromus timidus* Hagea, and *Bacca pulcherrima* were recorded at Malihabad.

#### 2.5.12 Oriental Fruitfly, *Dacus dorsalis* (Hend.)

Out of the fruitfly puparia shipped from north India *Bracon fletcheri* Silv., *Opius incisi* Silv., *O. watersi* (Full.) *O. longicaudatus* (Ashm.), *O. fletcheri* Silv., *O. vandenboschi* Full., *Cratospila* sp., *Spalangia afra* Silv., *S. endius* Wlk., *Dirhinus luzonensis* Roh., *D. giffardii* Silv., *Pachycrepoideus vindemmiae* (Rond.) *Cynipidae* sp., *O. carpomyiae* (Silv.), *Psilus* sp., *Trichopria* sp. and *O. oophilus* Full. (Weber, 1951), and from South India, *Opius persulcatus* (Silv.), *O. oophilus*, *O. compensans* (Silv.), *O. incisi*, *O. manii* Full., *O. carpomyiae*, *Aceratoneuromyia indicum* (Silv.), *S. endius*, *S. afra*, *S. grotiuse* Gir., *D. giffardii*, *D. luzonensis* Rohw., *P. vindemmiae*, *Trichopria* sp., *Trybliographa daci* Weld., *Pseudeucoila* spp., *Cothonaspis* spp., two *Psilus* spp., *Halticoptera* sp., unidentified *Alysiinae*, *Tachinaephagus* sp. and *Cratospila* sp. were recorded (Clausen *et al.*, 1965). Seventeen species of parasitoids were reported to be associated with mango fruitflies (Narayanan and Batra, 1960) but recent surveys indicate that many parasitoids reported earlier are not available.

#### 2.5.13 Mango Nut Weevil, *Sternochetus mangiferae* (Fabr.)

Nuclear polyhedrosis virus was recorded from Bangalore (Shukla *et al.*, 1984), *St. gravis* (Fabr.) was preyed upon by ants - *Oecophylla smaragdina*, *Camponotus* sp. and *Monomorium* sp.; fungus *Aspergillus* sp. and mite *Rhizoglyphus* sp. developed on larvae, pupae and hibernating adults in Tripura (De and Pande, 1988).

#### 2.5.14 Mango Mites

Among different species of mites, attacking mango in Gujarat, the web spinning eriophyid phytophagous mite, *Cisoberoptus kenya* Keifer was most prevalent compared to other tetranychid phytophagous mites, viz., *Tetranychus cinnabarinus* Boisduval and *Oligonychus mangiferus* Rahman and Sapra. Population of predatory mite *Amblyseius* sp. (0.12 to 1.17 mite/leaf) was noticed throughout the year with peak in June (6.21 mites/leaf) (Patel *et al.*, 1989).

#### 2.5.15 Other Pests

*Stagodyphus sarasinorum* was recorded on *Haltica* sp. at Malihabad. The predacious pentatomid bug, *Cantheconidea furcellata* (Wolff.) was found predating on

all instars of larvae as well as freshly formed pupae of *Parasa lepida* (Cramer) at Bangalore (Ghorpade, 1972). Mango flea weevil, *Rhychaenus mangiferae* Mshll. was found to be parasitised by *Cirrospilus quadristriatus* (Subba Rao and Ramamani), *Teleopterus* sp., *Euderus* sp. and *Sphegigaster* sp. (Peter and Balasubramanian, 1984).

Very little efforts have been made to utilise the natural enemies of mango pests. The entomopathogenic fungus, *Verticillium lecanii*, has been evaluated against mango hopper at Lucknow (Anon., 1980). Although *V. lecanii* has been isolated from the hoppers, yet results of its sprays (without creating artificial humidity around the plants) were poor. To improve the efficacy of the fungus, efforts are now being made with humid conditions.

## 2.6 Other Fruits

From pomegranate butterfly, *Deudorix epijarbas* Moore, egg parasitoids *Anastatus* sp. nr. *kashmirensis* Mathur, *Aphelinus gossypii* Timberlake, *Telenomus cyrus* Nixon (?); larval parasitoids, *Apanteles? obliquae* Wilkinson and *A. vitripennis* Hal. have been reared in Kullu, Himachal Pradesh (Thakur *et al.*, 1988). The braconid *A. vitripennis* has been recorded for the first time from this host (Rawat *et al.*, 1988a). Caterpillars of *Virachola isocrates* Fab. were parasitised by *Brachymeria euploae* (Narayanan, 1954). Mealy bugs, *Planococcus lilacinus* (Ckll.) and *P. citri* are important pests of pomegranate. *P. lilacinus* was predated by *Spalgis epius*, *Hyperaspis maindroni* Sic., *Scymnus severini* Weise, *S. coccivora*, *Cryptolaemus*, *montrouzieri*, *Eublemma* sp., *Leucopis luteicornis* Malloch, and parasitised by *Anagyrus* sp. and *Leptomastix dactylopii* (Nair, 1975; Anon., 1988).

Scale insect, *Parasaissetia nigra* (Nietner), is a very serious pest of pomegranate in Maharashtra. It was parasitised by pteromalid *Scutellista cynea* Mots (Jadav and Ajri, 1981). The lycaenid, *Spalgis epius* Westw. was found to be an efficient predator of mealy bugs infesting custard apple and pomegranate (Anon., 1987).

In pineapple, substantial control of the mealy bug, *Dysmicoccus brevipes* (Cockerell) in Hawaii has been obtained with the introduction of *Anagyrus coccivorus* Dozier and *Hambletonia pseudococcina* Comp. from Brazil and *Vincentodiplosis pseudococci* (Felt.) from Mexico (Carter, 1944, 1945). Efforts are being made to introduce suitable parasitoids of pineapple mealy bug. As far as mealy bugs are concerned, the technology for their suppression on citrus, guava, grapes, custard apple, *ber* and other fruits is available.

*Phytoselius intermedius* Evans and Macfarlane, *Typhlodromus fleshneri* Chant and an undescribed species of *Phytoselius* have been recorded attacking litchi mite, *Aceria litchi* (Keifer) (Sharma, 1983). Larvae and adults of *Stethorus keralicus* Kapur were observed feeding on all stages of *Raoiella indica* Hirst infesting rose apple (*Syzygium jambos*) at Bangalore (Nageschandra and Channa Basavanna, 1983). Entomopathogenic micro-organisms have been multiplied and their effectiveness demonstrated.

On banana, field testing of nuclear polyhedrosis virus on *Spodoptera litura* in Madurai district revealed that the pest could be controlled effectively with a dose of  $1.2 \times 10^{12}$  polyhedral inclusion bodies (PIB) per hectare (Santharam *et al.*, 1978).

There is hardly any fruit pest which is free from natural enemies, but very little effort has been made to utilise these natural enemies for the control of fruit pests.

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